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Old Growth in Northwestern California National Forests

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Abstract

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This report estimates old-growth forest area and summarizes stand characteristics of old growth in northwestern California National Forests by forest type. Old-growth definitions for each forest type are used.

Keywords: Old growth, inventory, forest stands, forest area, California, National Forests, Douglas-fir, white fir, red fir, Jeffrey pine, ponderosa pine, lodgepole pine, mixed conifer, mountain hemlock, mixed subalpine.

Summary

Pristine old-growth forests cover about 390,000 acres of the northwestern California National Forests. Two-thirds of the pristine old growth is in Douglas-fir forest types, and one-third is in the following forest types: white fir, red fir, Jeffrey pine, lodgepole pine, mixed conifer, and mixed subalpine-mountain hemlock. No pristine old growth exists in the Pacific ponderosa pine, interior ponderosa pine, mixed subalpine-western white pine, or mixed subalpine-white fir/Jeffrey pine forest types in northwestern California National Forests. Structural characteristics of old growth differ by forest type.

Introduction

Old-growth forests, long valued as a source of high-quality timber, are important as wildlife habitat and central to issues of genetic reserves, biodiversity, climate change, and nutrient cycling. As the area of old-growth forests decreases, the debate over their value intensifies, and a clear understanding of the amount and distribution of old growth becomes more crucial. The purpose of this paper is to report the area of old growth in northwestern California National Forests and to summarize the area and characteristics of old growth in those forests by forest type. Previous estimates of old-growth area in northwestern California were made by using a generalized description of old growth and data from inventories which did not measure many of the key components of old growth. For this paper, we used an old-growth definition for each Society of American Foresters (SAF) forest type (Eyre 1980) and each site class, and we used data from an inventory of the productive forest land[1] in northwestern California National Forests conducted in 1992 and 1993 that was designed to measure live vegetation, stand structure, and standing and down dead trees.

The area in northwestern California covered by this paper is shown in figure 1. The terrain generally is rugged and steep and comprised of a complex of mountain ranges including Mount Shasta, the Siskiyou Mountains, the Klamath Mountain Ranges (Marble, Trinity, Salmon, and Scott Mountains) and the northern California Coast Ranges (figs. 2-5 show examples of the terrain). Conifers dominate the forests in these mountains, and many species are capable of living hundreds of years.

The climate of northwestern California consists of wet winters and warm, dry summers. Maritime influences make the low- and mid-elevation forests of the northern California Coast Ranges, the western part of the Siskiyous, and the Salmon and Trinity Mountains distinctive from the low- and mid-elevation forests of the central Trinity, eastern Salmon, and eastern Trinity Mountains and the slopes of Mount Shasta. On the western border of this region, low-elevation Douglas-fir/tanoak type (Douglas-fir/tanoak/Pacific madrone, SAF type 234) forests (500-3,400 feet) give way to mid-elevation Pacific Douglas-fir (SAF type 229) forests (2,400-5,300 feet). The difference between the two Douglas-fir forest types is primarily a reduction in the hardwood component in the Pacific Douglas-fir type. In the eastern part of the Klamath region, Pacific ponderosa pine (SAF type 245) and interior ponderosa pine (SAF 237) forests (800-5,000 feet) grade into mixed-conifer (Sierra Nevada mixed-conifer, SAF type 243)[2] forests (4,500-6,000 feet). Douglas-fir forests and mixed-conifer forests are characterized by species diversity and a complex forest structure with many layers of vegetation beneath a conifer overstory. The Pacific and interior ponderosa pine forest types generally are open with few other tree species in the overstory and an understory of low shrubs and grass.

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[1] Forest land is land covered at least 10 percent by crowns of live trees. Productive forest land is land capable of producing 20 cubic feet or more per acre per year in continuous crops of industrial wood. The inventory did not measure the old growth of "non productive" forest land, such as oak woodlands.

[2] The mixed-conifer forest type is called Sierra Nevada mixed conifer by the Society of American Foresters (SAF type 243) because it is most commonly found in the Sierra Nevada mountains. Because the forest type exists in the Klamath region, we have called the type simply mixed conifer.

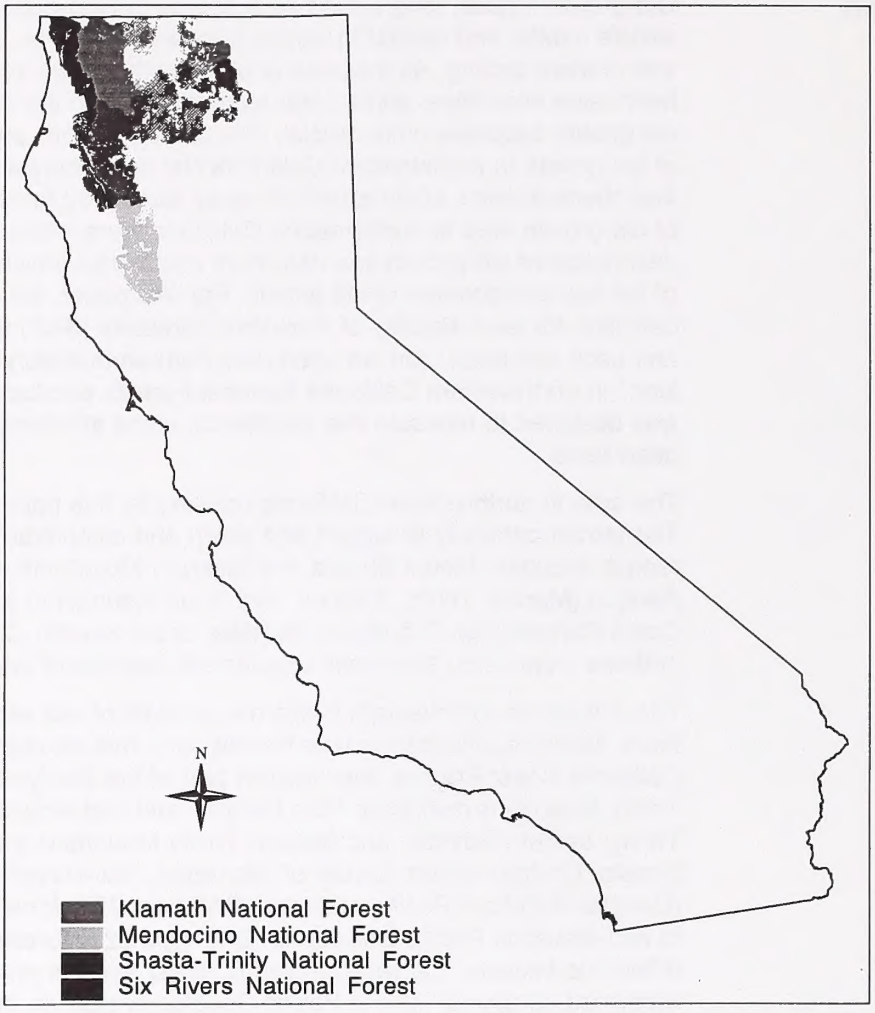

Figure 1—Location of National Forests in northwestern California.

Figure 2—View of the Siskiyou Mountains looking south from the Oregon border.

Figure 3—View of the Marble Mountains looking north from Etna summit.

Figure 4—The eastern slopes of Mount Shasta.

The low- and mid-elevation forests in the area covered by this paper have been altered by natural and human-caused disturbance. The natural fire regime in the Klamath region in forest types dominated by Douglas-fir[3] or ponderosa pine is characterized by frequent, low-intensity fires (Agee 1993), though there have been a few large wildfire events. Past human-caused disturbances such as burning to clear the understory or to create forage, mining, and the logging associated with mining activities also affected the Douglas-fir types of the Klamath region. Since the introduction of fire-exclusion practices, logging has had the greatest influence on the low- and mid-elevation forests in this region. Clearcuts in the Douglas-fir and mixed-conifer types have left patches of forest in primarily younger seral stages. Selective logging practices have removed many of the Douglas-fir and ponderosa pine trees in the mixed-conifer forest type and altered stand structure in both the Pacific and interior ponderosa pine types by removing most of the older, larger trees. Although the fire-exclusion practices may have protected some areas of old-growth forest in the region from human-caused fires, the practice has influenced the species composition and forest structure of the mixed-conifer and ponderosa pine types. The natural fire regime in the mixed-conifer type tended to favor Douglas-fir and ponderosa pine, but with fire suppression, many stands are slowly converting to white fir. In addition, fire suppression has altered the forest structure and created a buildup of fuels to such an extent that a natural fire in such an unnatural situation might put any remaining old-growth forests at risk.

[3] The scientific names of trees, shrubs, and forbs are listed in appendix C.

Figure 5—View of the Siskiyou Mountains looking east from USDA Forest Service Road no. 16 in the Six Rivers National Forest.

True fir forests are at higher elevations across the Klamath and Mount Shasta region where much of the winter precipitation is snow. White fir (SAF 211) forests occur in an elevation band from 4,500 to 5,500 feet and red fir (SAF 207) forests from 6,000 to 9,000 feet. White fir and red fir forests are characterized by dense, monotypic overstories with sparse understories. Above the red fir forests are the mixed subalpine (California mixed subalpine, SAF 256) forests of mountain hemlock, foxtail pine, or whitebark pine. In the subalpine forests, the environment is harsh, snow cover is heavy, and the soil is thin. Tree species in this forest type are known for their longevity and slow growth. The lodgepole pine (SAF 218) forest type is scattered throughout the region covered by this paper though primarily at higher elevations (above 5,000 feet). The forests often are found on microsites that are cooler, with poorer drainage than the surrounding area. Although fire is one of the natural disturbances in the higher elevation forest types—red fir, lodgepole pine, and the mixed subalpine forest types—it is much less frequent than in the lower elevation forest types. In addition, these forest types have been less disturbed by humans, although logging has become a more common source of disturbance in the red fir forest type.

Jeffrey pine (SAF 247) is a forest type more commonly found on the east side of the Sierra Nevada. In the Klamath region, the type is found on granitic ridgetops and on serpentine soils and has been relatively undisturbed by humans.

Source of the Data

Sampling design—A stratified random sampling design was used in the USDA Forest Service Pacific Southwest Region (Region 5) inventory (USDA Forest Service 1994). Vegetation was mapped for each National Forest by using natural color aerial photography, and all acres of National Forest ownership were divided into homogeneous stands of 5 acres or larger. Each stand was labeled as to major forest type, tree crown size, and tree crown closure by using photo interpretation techniques and defined classes. The year and scale of the photography differed by Forest: 1970 at a scale of 1:15,840 for the Six Rivers; 1975 at a scale of 1:24,000 for the Klamath; 1978 at a scale of 1:24,000 for the Shasta-Trinity; and 1979 at a scale of 1:15,840 for the Mendocino. Stand boundaries were transferred from photos to 7.5-minute U.S. Geological Survey (USGS) quadrangle maps of 1:24,000 scale and entered into a geographic information system (GIS). Updates for major changes in stand structure due to wildfire or harvest were made by using ortho photography at a scale of 1:24,000, and the updated information was entered into the GIS system.

Random sample areas (a sampling area with a 0.7-mile radius, hereafter called RSAs) were assigned proportionately to the size of a particular National Forest and to the number of RSAs necessary to select a minimum of 20 stands from each stratum (the combination of forest type, crown size, and crown cover) of a Forest. The locations of RSAs were placed by randomly choosing townships, ranges, and sections from all the townships, ranges, and sections on each National Forest. If an RSA fell in private land or more than 50 percent of the circle was on private land, it was eliminated. If two or more RSAs overlapped, the second one was eliminated.

Random sample areas were transferred to 1:24,000 quadrangle maps on which stands and strata labels had been plotted. Stands were selected for inventory if they were wholly or partially within the 1,000-acre circle of the RSA. Stands were eliminated if they were not large enough for four points. Thus, no stand was smaller than about 5 acres. Each stand was numbered and then listed by timber strata for all RSAs. By using a random number generator, a minimum of 20 stands per forest stratum were selected. Stands were plotted on 1:24,000 ortho photography. For the Mendocino National Forest, 7.5-minute USGS quadrangle maps were substituted for the RSAs in the first stage of sampling.

In total, 1,244 plots were installed at the Six Rivers, Klamath, Shasta-Trinity, and Mendocino National Forests. The acre expansion for each plot in the current analysis was the number of acres in the stratum of the plot for a particular National Forest divided by the total number of plots in that stratum at that National Forest.

Field plot design—Each plot consisted of a minimum of 4 and a maximum of 10 points depending on the size of the stand to be measured (USDA Forest Service 1994). The design of the field plots was a nested plot design: at each point a variable-radius prism plot was used to tally live trees >5 inches diameter at breast height (d.b.h.) and a ½-acre circular, fixed-radius vegetation plot was used to tally percentage cover of vegetation layers. Between each point was a ½-acre rectangular fixed plot 66 feet wide and 330 feet long to tally large-sized snags (snags ≥20 inches d.b.h. and ≥6 feet tall) and nested within that ½-acre plot was a ¼-acre rectangular fixed plot 33 feet wide and 330 feet long to measure small-sized snags (snags >8 and <20 inches d.b.h. and ≥6 feet tall) and downed logs (logs ≥10 inches diameter at large end and ≥10 feet long).

Points were laid out in north-south transects (where possible), with transects at least 198 feet apart. All points were kept within stand boundaries; no point was located closer than 99 feet from the stand boundary, and no more than five points were placed in any single transect line.

Measurements on trees, snags, and logs—All live trees tallied were coded for species, d.b.h. to 2-inch diameter class, crown position, crown ratio, mistletoe rating, and defect. The defect codes assigned were minimal. They were designed to capture decay of old trees, not to aid in the computation of the net volume of a tree. Height and age were measured only on certain trees—at least one tree on every other point, for the determination of site class. Heights were estimated by using equations for all trees where height was not measured in the field. Tree heights were predicted from tree diameter and site index. Because age was measured on relatively few trees, the age of the oldest tree measured on a plot was not particularly useful to assign an age to the stand. We used the ages of the trees in this paper only for comparisons across species and forest types.

All snags tallied were coded for species, d.b.h. to 2-inch diameter class, decay class, and height to the nearest 10 feet. All downed debris (logs) were coded for species, diameter at the large end to a 2-inch diameter class, length to the nearest 10 feet, and decay class.

Vegetation layers and measurements for percentage of cover—The ½-acre fixed radius vegetation plot at each point was divided into two understory layers. One layer (layer 4) was comprised of seedlings and saplings (all trees less than 5 inches d.b.h.) and shrubs; and the second (layer 5) was comprised of forbs and grasses. Each layer was described by percentage of cover and species in the following way: within layer 4, conifers were given a total percentage of cover, or zero if all conifers comprised less than 10 percent cover, and an average height. The species names of the three most abundant conifer species were recorded. Also, within layer 4, hardwoods were given a total percentage of cover, or zero if all hardwoods comprised less than 10 percent of cover, and an average height. The species names of the three most abundant hardwood species was recorded. And within layer 4, shrubs were given a total percentage of cover or zero and the species names of the three most abundant species were recorded. All percentages in layer 4 could add up to no more than 100 percent for the whole layer. Within layer 5, the percentage of cover for all the herbs and grasses and the species name of the single most abundant species were recorded. No height was recorded for layer 5. Because only the most abundant understory species were recorded, species diversity in old growth and across types could only be approximated.

Stand level data—Each stand was assigned a site index, aspect, slope, and elevation. One of the following four codes was assigned in the field to describe stand structure: (1) even-aged and single-storied, (2) even-aged and two-storied, (3) uneven-aged with three or more structural layers, or (4) a mosaic consisting of a group of distinct size classes each of which may or may not be even aged. Because age was measured on relatively few trees in a stand to substantiate these stand structure codes, the terms "even-sized" or "uneven-sized" are used in the current paper rather than "even-aged" and "uneven-aged" when referring to upper canopy structure.

The five codes to identify disturbance history were (1) no evidence of timber management or wildfire, (2) evidence of timber management within the past 20 years, (3) evidence of management more than 20 years ago, (4) evidence of wildfire but no evidence of management, and (5) evidence of wildfire and timber management within the last 20 years. These codes allowed us to separate those stands that had been disturbed by humans (codes 2, 3, or 5) from those that were essentially unmanaged (codes 1 and 4). Finally, any special habitat feature found was shown on the plot diagram and coded.

The Old-Growth Definitions

Old-growth definitions for the major Society of American Foresters (SAF) (Eyre 1980) forest types in California were developed by a team of Region 5 scientists (Fites and others 1991a, 1991b; Jimmerson 1991a, 1991b; Potter 1992a, 1992b, 1992c, 1992d; Smith and others 1991, Smith 1991). The old-growth definitions for the following SAF forest types were used in the current paper:

SAF code	Forest type
234	Douglas-fir/tanoak
229	Pacific Douglas-fir
211	White fir
207	Red fir
245	Pacific ponderosa pine
237	Interior ponderosa pine
247	Jeffrey pine
218	Lodgepole pine
243	Mixed conifer
256	Mixed subalpine:
	Western white pine subtype
	Mountain hemlock subtype
	White fir-Jeffrey pine subtype

No old-growth definition was developed for SAF forest type Pacific ponderosa pine/ Douglas-fir (SAF 244). This type does exist in the southern part of the Six Rivers and the northern part of the Mendocino National Forests, but due to the similarity of species, Region 5 ecologists decided that the mixed-conifer old-growth definition could be used for stands of this forest type. In addition, Region 5 ecologists judged that old-growth white fir in the Six Rivers National Forest and the westernmost part of the Klamath National Forests was different enough in structure from old-growth white fir in the rest of California, especially as to the presence of snags and logs, to warrant a unique old-growth definition. Therefore there are two definitions for old-growth white fir: White fir-a for the white fir type in the Six Rivers and westernmost part of the Klamath National Forests; and white fir-b for the white fir type elsewhere in California. (Fites 1991b). The mixed subalpine type was subdivided into five subtypes, and separate definitions were written for these five subtypes. Three of these subtypes (listed above) apply to the area in this paper. No definitions were developed for productive hardwood types.

The objective of the researchers was to identify by site class and forest type those characteristics that would indicate the onset of an old-growth stage. Each of the old-growth definitions included the following structural attributes: stand age, size and density of the large-sized trees, size and density of large-sized snags and logs, the variation in canopy layers and tree diameters, and the presence of decay in live trees. A detailed description of the development of each old-growth definition can be found in the individual reports (Fites and others 1991a, 1991b; Jimmerson 1991a, 1991b; Potter 1992a, 1992b, 1992c, 1992d; Smith and others 1991, Smith 1991). A brief summary of the methods used to arrive at the definitions and a table of the key components of each old-growth definition is in appendix A.

Methods Used to Compile the Inventory Data

Each stand in the current inventory was typed as one of the above SAF forest types by using a key (see appendix B). The key uses the relative basal area of each species tallied on a plot, and for some types, the geographic location of the plot. The key follows closely the one used by the Region 5 scientists who developed the old-growth definitions so that there would be no overlap among forest types. It should be noted, however, that the plots used by the scientists to develop the old-growth definitions may not have been representative of the full extent of a particular forest type. For example, no plots were selected from the Shasta-Trinity or Mendocino National Forests to develop the old-growth definitions for the Douglas-fir types.

A stand was classified as large-sized sawtimber if the quadratic mean diameter of the codominant and dominant trees was at least 21 inches. A stand also was classified according to how well it met key structural attributes of old growth; that is, whether the stand had a sufficient density of large-sized live trees to be considered old growth and, if so, whether it had enough large-sized snags and logs per acre. "Large" was defined for each forest type (see table 12 in appendix A). "Pristine" old-growth stands were those that met the minimum criteria for live trees, snags, and logs and, in addition, were undisturbed by humans. Finally, stands were classified as to their "potential" to be old growth. These were stands that had enough trees just smaller than the minimum size for the particular forest type which could reasonably be expected to grow into the old-growth size class if left undisturbed for 30 years.

Results

Old-Growth Area

There are 3.9 million acres of productive forest land in northwestern California National Forests, and two-thirds of the productive forest land is comprised of sawtimber-sized stands (table 1). Mixed-conifer, Douglas-fir/tanoak, Pacific Douglas-fir, white fir and red fir forest types together comprise 90 percent of the area in sawtimber. Roughly one half of the sawtimber forest land is large-sized sawtimber composed of stands where most of the trees are at least 21 inches in diameter. Forty-two percent of the large-sized sawtimber area (670,152 acres) has a sufficient number of large-sized trees per acre (for most forest types "large" means trees at least 30 inches in diameter) to be classified as old growth as defined by the ecological definitions used in this paper. Thus, 13 percent of the total forest land in northwestern California National Forests could be considered old growth (see table 1).

Table 1—Area of forest land, productive forest land and productive forest land that meets old-growth criteria in northwestern California National Forests

Forest land category	Land area	Percent of total forest land
	Acres	*Percent*
Total forest land	5,155,020	100
Productive forest land[a]	3,861,784	75
Sawtimber forest land[b]	3,387,192	66
Large sawtimber forest land[c]	1,574,751	31
Forest land that meets old-growth criteria:		
Meets large, live tree minimums	670,152	13
Meets trees + snags minimums	581,991	11
Meets trees + logs minimums	566,874	11
Meets trees + snags + logs minimums	511,594	10
Meets trees + snags + logs minimums and is pristine	390,777	8

[a] Capable of growing 10 percent cover of industrial wood species.
[b] Ten percent crown closure and an average crown diameter greater than 12 feet.
[c] Average diameter of codominant, dominant, and predominant trees is ≥21 inches.

A previous estimate of 651,000 acres of old growth for these same National Forests was reported in 1993 by the Pacific Northwest Reseach Station (Bolsinger and Waddell 1993). This estimate was arrived at by aggregating the acres of the timber strata (identified through photo-interpretation techniques) that were most likely to meet the old-growth criteria of the Old-Growth Definition Task Group (1986). The similarity of the two estimates may be coincidental because in the current analysis, some old-growth area was found in just about all the timber strata in the National Forests, not just in the large-sized sawtimber strata that were used to make the previous estimate. In addition, much of the large-sized sawtimber strata was not old growth by the definitions used in this paper.

Ecologists recognize that an area functions as old growth not only because there are large-sized old trees but also because there are large-sized standing dead trees (snags) and downed debris (logs) (figs. 6-9). Density of snags and logs were criteria in 8 of the 13 old-growth definitions used in this paper (see table 12 in appendix A). If a minimum density of snags and logs for these forest types are added as essential characteristics of old growth, the area of old growth in northwestern California National Forests is 511,594 acres. One-quarter of these 511,594 acres has been disturbed by humans. Thus, 8 percent of the total forest land (390,777 acres) meets the minimum tree, snag, and log criteria in each forest type and is classified as pristine old growth (see table 1).

Figure 6—Sugar pine tree with a dead top.

Figure 7—Snag with cavity.

Figure 8—Coarse woody debris on the forest floor of Douglas-fir/tanoak old growth.

Figure 9—Fallen tree in an interior ponderosa pine stand.

Although snags and logs are characteristic of old growth, they are not unique to old growth. In the current inventory, we found that stands that did not have the requisite density of large-sized trees to be classified as old growth had, on average, nearly as many snags and logs (at least 20 inches in diameter) per acre as did old-growth stands (see table 2). This would suggest that snags and logs, as a legacy of past disturbances, may be in place before a stand has enough large, old trees to be classified as old growth.

Potential Old-Growth Area

We estimate that 5 percent of the forest land in northwestern California National Forests that is not old growth today has the potential to be old growth, as classified by the density of large-sized trees, in 30 years. This estimate assumes that no harvesting or severe natural disturbance occurs in these forests over the next three decades and that trees at least 28 inches in diameter are able to grow 2 inches in diameter in 30 years. If we also assume that the acres of potential old growth will retain the density of snags and logs they have today and remain pristine, 121,668 acres could have the full characteristics of old growth in 30 years. Pristine old growth would then increase from 8 percent to 10 percent of the total forest land in northwestern California National Forests.

Table 2—Density of standing dead trees (snags) and downed dead trees (logs) at least 20 inches in diameter in old-growth stands and stands that are not old growth in northwestern California National Forests

Forest type[a]	Snags						Logs					
	Stands that are old growth[b]			Stands that are not old growth			Stands that are old growth[b]			Stands that are not old growth		
	n[c]	$\bar{x}$[d]	(se)[e]	n	$\bar{x}$	(se)	n	$\bar{x}$	(se)	n	$\bar{x}$	(se)
Douglas-fir/tanoak	68	2	(0.2)	120	2	(0.2)	68	8	(0.9)	120	5	(0.5)
Pacific Douglas-fir	65	4	(0.3)	151	2	(0.2)	65	9	(0.5)	151	8	(0.5)
White fir-a[f]	11	5	(0.5)	22	4	(0.5)	11	5	(1.1)	22	3	(0.6)
White fir-b[g]	14	5	(0.9)	124	4	(0.3)	14	7	(1.5)	124	7	(0.5)
Red fir	46	5	(0.6)	99	3	(0.2)	46	9	(0.8)	99	7	(0.5)
Interior ponderosa pine	4	1	(0.1)	45	0		4	2	(0.5)	45	2	(0.3)
Jeffrey pine	7	2	(0.8)	11	1	(0.4)	7	5	(1.4)	11	4	(0.8)
Lodgepole pine	4	2	(0.9)	30	1	(0.3)	4	4	(1.6)	30	4	(0.5)
Mixed conifer	36	4	(0.3)	337	2	(0.1)	36	7	(0.7)	337	6	(0.3)
Mixed subalpine-western white pine	2	3	(2.6)	12	2	(0.5)	2	5	(0.8)	12	5	(1.6)
Mixed subalpine-mountain hemlock	14	4	(0.5)	17	3	(0.4)	14	9	(1.4)	17	5	(0.9)

[a] Two forest types are not included in this table. Pacific ponderosa pine type had only 1 old-growth stand and 2 stands that were not old growth. Mixed subalpine-white fir/Jeffrey pine had no old-growth stands and 2 stands that were not old growth.
[b] Stands that have a minimum number of large-sized, live trees to be considered old growth.
[c] n = number of stands.
[d] $\bar{x}$ = mean.
[e] (se) = standard error.
[f] White fir type in the Six Rivers and western Klamath National Forests.
[g] White fir type in the Mendocino, Shasta-Trinity, and eastern Klamath National Forests.

Old-Growth Area by National Forest

About 200,000 acres in the Six Rivers, Klamath, and Shasta-Trinity National Forests and 65,000 acres in the Mendocino National Forest meet the minimum density of large-sized live trees to be considered old growth (see fig. 10). The Six Rivers, Klamath, and Shasta-Trinity National Forests each have about 100,000 to 125,000 acres of pristine old growth. The Mendocino has about 38,000 acres of pristine old growth. The proportion of pristine old growth to total productive forest land is greatest in the Six Rivers National Forest. Eighteen percent of the productive forest land in that Forest is pristine old growth, whereas less than 10 percent on each of the other three National Forests is pristine old growth.

The Klamath National Forest would have the biggest gain in old-growth area over the next three decades if no major disturbance occurred. Forty-seven percent of the 247,075 acres of potential old growth (by the minimum density of large-sized trees) is in the Klamath Forest, 30 percent is in the Shasta-Trinity, 16 percent is in the Six Rivers, and 7 percent is in the Mendocino. The relation is similar for the 121,668 acres of old growth that potentially could have the full structural characteristics of old growth. Fifty-four percent is in the Klamath, 35 percent is in the Shasta-Trinity, 7 percent is in the Mendocino, and 4 percent is in the Six Rivers.

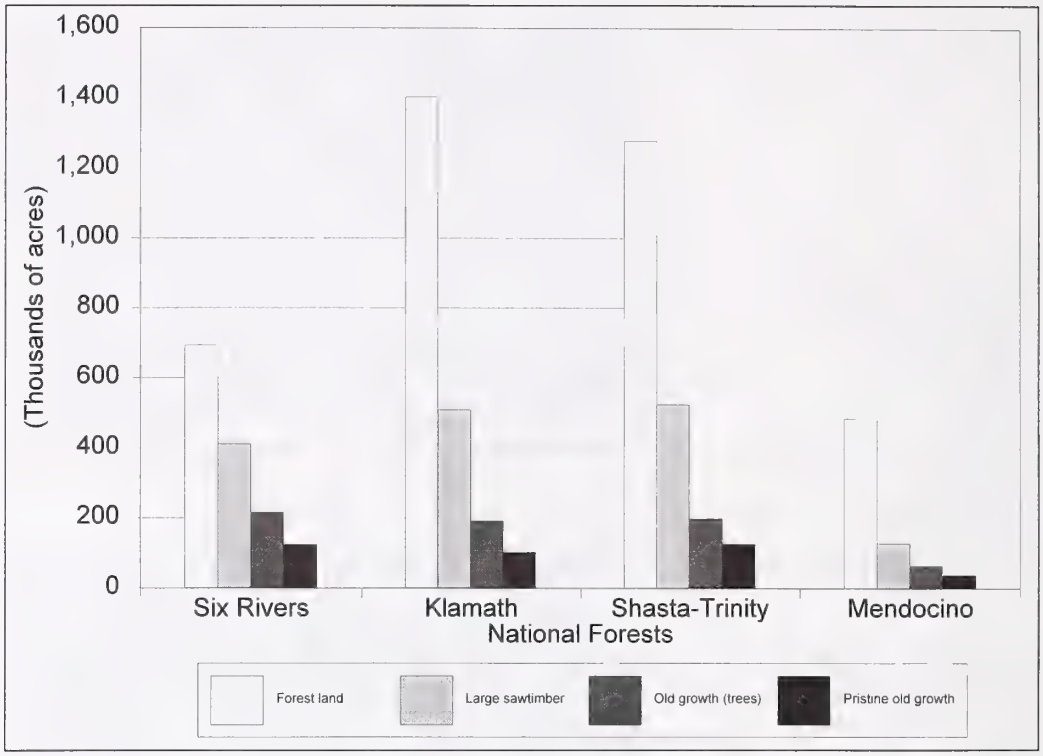

Figure 10—Area of productive forest land, productive forest land of large-sized sawtimber stands, old growth, and pristine old growth in northwestern California by National Forest.

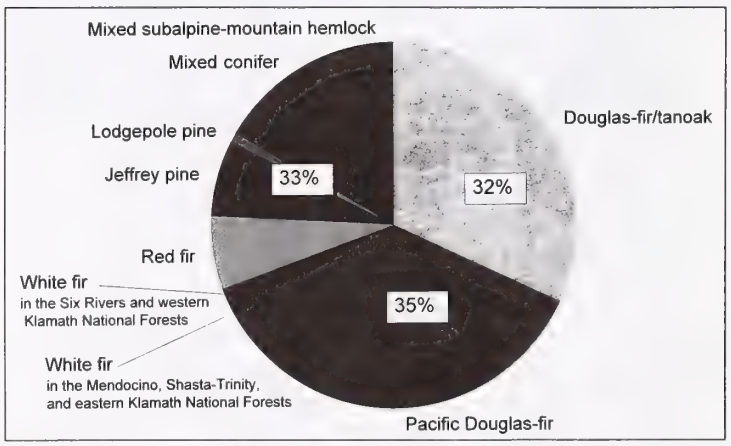

Figure 11—Proportion of pristine old-growth area in northwestern California National Forests in each forest type.

Old-Growth Area by Forest Type

As shown in fig. 11, two-thirds of the pristine old growth is in the Douglas-fir types—Douglas-fir/tanoak and Pacific Douglas-fir—and one third is in seven other forest types. Figure 12 shows what percentage of a type's sawtimber is pristine old growth. None of the stands sampled in Pacific ponderosa pine, interior ponderosa pine, and two mixed subalpine types (western white pine and white fir-Jeffrey pine) in northwestern California National Forests was found to be pristine old growth.

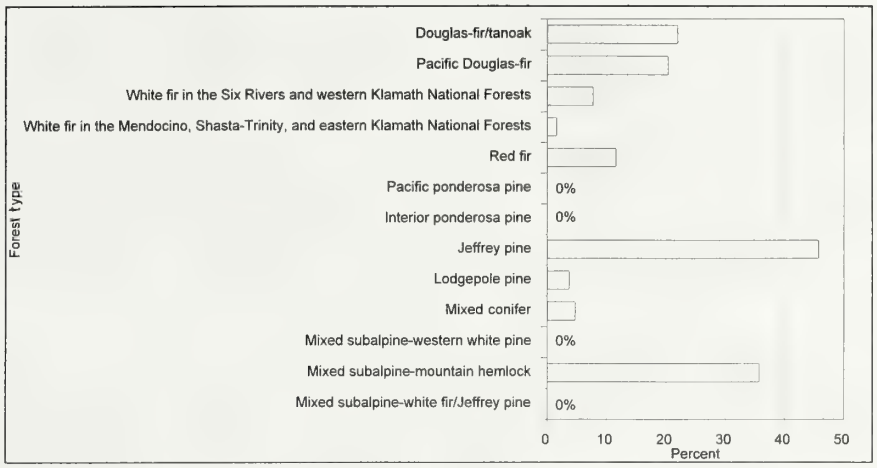

Figure 12—Pristine old-growth area as a percentage of the area of productive forest land in sawtimber stands.

Figure 13—Interior ponderosa pine stand east of Mount Shasta. The stand qualifies for old growth, but there is evidence of harvest.

Harvesting has probably had the greatest influence on the amount of old growth in the Pacific ponderosa pine, interior ponderosa pine, mixed-conifer and white fir types. The ponderosa pine types are more accessible than some of the other forest types as they are in flat terrain and at lower elevations. All of the Pacific ponderosa pine type and 90 percent of the interior ponderosa pine type in this inventory have had evidence of human disturbance (see fig. 13). Much of the mixed-conifer forest in northwestern California National Forests has been selectively harvested many times. Large-sized, old trees exist in the mixed-conifer type, but they are widely distributed, and there are few untouched areas where the density of old-growth characteristics is sufficient for the area to be classified as old growth.

The Jeffrey pine type is of limited extent in northwestern California National Forests. As most of the Jeffrey pine type in these forests is on low productivity, ultramafic soils or high granitic ridges, it has been left relatively undisturbed by harvest activities. The mixed subalpine-mountain hemlock type is also of limited extent in northwestern California National Forests. The high percentage of mountain hemlock sawtimber (36 percent) that is in pristine old growth is probably due to three factors: (1) it is less commercially available because it grows in inaccessible, steep reaches of the forested mountains and most of the type is in designated wilderness; (2) it is less commercially desirable due to its growth form; and (3) the natural disturbance in this forest type, though severe, is infrequent (Agee 1993).

Forty-one percent of the 121,668 acres of sawtimber area that have the potential to be pristine old growth in 30 years is in the two Douglas-fir types; 59 percent is in 10 other forest types (see table 3). The area of potential old growth in white fir, interior ponderosa pine, mixed subalpine-western white pine and mixed subalpine-white fir/Jeffrey pine forest types is greater than the current levels of old growth in these types. The area of pristine old growth in mixed-conifer and red fir forests could increase by half.

Table 3—Area of forest land in sawtimber stands, current old-growth stands, and potential old-growth stands by forest type in northwestern California National Forests

Forest type	Sawtimber	Current pristine old growth[a]	Potential pristine old growth[b]
		Acres	
Douglas-fir/tanoak	569,232	124,738	37,971
Pacific Douglas-fir	668,240	136,178	11,629
White fir-a[c]	58,554	4,501	8,823
White fir-b[d]	346,798	5,558	7,518
Red fir	217,608	25,330	12,890
Pacific ponderosa pine	11,610	0	0
Interior ponderosa pine	120,507	0	881
Jeffrey pine	58,510	26,761	649
Lodgepole pine	78,737	2,923	955
Mixed conifer	1,195,380	55,732	35,828
Mixed subalpine-western white pine	32,263	0	927
Mixed subalpine-mountain hemlock	25,358	9,056	2,388
Mixed subalpine-white fir/Jeffrey pine	4,396	0	1,210
Total	3,387,192	390,777	121,668

[a] Area that meets the live trees, snags, and logs criteria and is undisturbed by humans.
[b] Area that could meet the live trees, snags, and logs criteria in 30 years and is undisturbed by humans.
[c] White fir type in the Six Rivers and western Klamath National Forests.
[d] White fir type in the Mendocino, Shasta-Trinity, and eastern Klamath National Forests.

Timber Volume in Old-Growth Forests

The gross sawtimber volume[4] in pristine old growth is 2.7 billion cubic feet or 20 percent of the total gross sawtimber volume in northwestern California National Forests. The current inventory was not specifically designed to estimate net volume of sound wood suitable for milling into lumber. The net volume in old-growth forests, however, is probably less than 20 percent of total net volume because of the high incidence of decay in old-growth trees. For most types, especially the Douglas-fir and mixed-conifer types which together comprise 74 percent of the sawtimber volume in old growth, the incidence of stem decay is greater in old-growth stands than in stands that are not old growth. In addition, 12 percent of the trees tallied in the old-growth forests were noted to have some form of defect in timber quality.

The Largest and Oldest Trees by Species

Table 4 shows the largest trees measured in this inventory in all forest stands by species. Trees were tallied in a random sample, and there may, indeed, be larger specimens in these forests. Table 4 does, however, indicate the relative sizes of the largest trees of each species, and the potential, given by the largest on record with the American Forestry Association, of each species. Although old growth may have a higher density of large-sized trees per acre than areas that are not old growth, the largest trees of a species often are not in old-growth stands. Sixty percent of the estimated number of trees in northwestern California National Forests that are at least 30 inches in diameter are not in old growth. In addition, out of the 36 tree species sampled in these forests, only 9 of the largest specimens were found in old-growth stands (table 4). The largest tree tallied in the inventory was a Douglas-fir 104 inches in diameter, and it was not found in old growth.

Area and Stand Characteristics of Old-Growth Types

The following section summarizes the characteristics of pristine old growth by forest type in terms of area, tree species diversity, percentage of large-sized trees by species (table 5), structure of the upper canopy (table 6), density of trees by size class (table 7), density of snags and logs (tables 8 and 9), overstory and understory percentage of cover (table 10), height of canopy layers (table 11), and incidence of decay. Where there were few pristine old-growth stands, reference is made to the characteristics of those stands having enough large-sized trees to be considered old growth.

Douglas-Fir/Tanoak Type

Area—The area of pristine Douglas-fir/tanoak old-growth type in northwestern California National Forests is 124,738 acres or 32 percent of the total pristine old growth of all forest types on these forests (table 3). Twenty-two percent of the 569,232 acres of Douglas-fir/tanoak sawtimber in these forests is currently pristine old growth. (Number of pristine old-growth stands = 37.)

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[4] Gross volume is the volume, above a 1-foot stump and up to a utilized top, of all trees at least 11 inches in diameter.

Text continues on page 22.

Table 4—Maximum diameter of trees by species measured in the inventory of northwestern California National Forests compared to maximum on record

Species	Largest diameter measured in inventory	Found in old growth (Y = yes)	Largest diameter on record[a]
	Inches		*Inches*
Softwoods:			
Douglas-fir	104		173
Incense-cedar	90		147
White fir	90	Y	107
Western juniper	86	Y	163
Sugar pine	82	Y	122
Ponderosa pine	80		91
Red fir	70	Y	102
Jeffrey pine	68		98
Mountain hemlock	62	Y	88
Western white pine	62		132
Port-Orford-cedar	56		144
Brewer spruce	52		52
Foxtail pine	46		101
Western redcedar	46		233
Englemann spruce	36		92
Whitebark pine	34	Y	105
Lodgepole pine	32		47
Gray pine	30		59
Knobcone pine	26		43
Pacific yew	20		56
Hardwoods:			
Pacific madrone	64		130
Canyon live oak	62		129
California black oak	60		108
Tanoak	60		109
Oregon white oak	48		87
Interior white oak	42		85
Giant chinkapin	38		43
Bigleaf maple	32		133
Red alder	28		78
California valley oak	26		111
Black cottonwood	20	Y	100
California-laurel	16		159
Aspen	12		39
Pacific dogwood	10	Y	54
Blue oak	8		77
Ash	6	Y	84

[a] The largest on record with the American Forestry Association (1988).

Table 5—Proportion of the estimated number of large-sized trees (≥30 inches in diameter) in each pristine old-growth forest type of species in northwestern California National Forests

Species	Pristine old-growth forest type								
	Douglas-fir/tanoak	Pacific Douglas-fir	White fir[a]	White fir[b]	Red fir	Jeffrey pine	Lodge-pole pine	Mixed conifer	Mixed subalpine-mountain hemlock
	Percent								
Douglas-fir	91	85	43	3	<1	1	15	45	
Ponderosa pine	<1	2			<1			5	
Jeffrey pine	<1			11	<1	73		2	
Sugar pine	2	6		11		3		13	
Western white pine									<1
Lodgepole pine									
Foxtail pine									
White fir		6	53	67	17	12	9	14	5
Red fir		<1	1	1	81		73	<1	47
Brewer spruce								<1	2
Mountain hemlock					<1		3		46
Incense-cedar	<1	<1	3	7		10		7	
Port-Orford-cedar	<1							8	
Western redcedar									
California black oak	<1	<1							
Canyon live oak	<1	<1						3	
Tanoak	3	<1							
Giant chinkapin								3	
Pacific madrone	3								

[a] White fir type in the Six Rivers and western Klamath National Forests.
[b] White fir type in the Mendocino, Shasta-Trinity, and eastern Klamath National Forests.

Table 6—Structure of pristine old growth by forest type in northwestern California National Forests

Forest type	Proportion of type with an even upper canopy[a]	Proportion of type with an uneven upper canopy[b]
	Percent	
Douglas-fir/tanoak	61	39
Pacific Douglas-fir	63	37
White fir-a[c]	73	43
White fir-b[d]	0	100
Red fir	40	60
Jeffrey pine	22	78
Lodgepole pine	0	100
Mixed conifer	57	43
Mixed subalpine-mountain hemlock	42	58

[a] Includes stands with 1 layer as well as stands with 2 layers where the overstory is even sized and presumed to be even aged.
[b] Includes stands with 3 or more distinct structural layers.
[c] White fir type in the Six Rivers and western Klamath National Forests.
[d] White fir type in the Mendocino, Shasta-Trinity, and eastern Klamath National Forests.

Table 7—Density of large-, medium-, and small-sized trees in pristine old-growth stands by forest type in northwestern California National Forests

Forest type	Number of stands	Large ≥30 inches in d.b.h. $\bar{x}$[a]	(se)[b]	Medium 20-28 inches in d.b.h. $\bar{x}$	(se)	Small 6-18 inches in d.b.h. $\bar{x}$	(se)
		Number of trees					
Douglas-fir/tanoak	37	13	(0.7)	12	(1.5)	171	(13.1)
Pacific Douglas-fir	37	17	(0.7)	9	(0.8)	109	(10.5)
White fir-a[c]	3	20	(3.7)	27	(3.5)	111	(47.6)
White fir-b[d]	5	12	(2.1)	21	(3.6)	78	(13.8)
Red fir	28	19	(1.2)	27	(2.5)	98	(12.2)
Jeffrey pine	6	7	(1.4)	12	(2.3)	68	(16.1)
Lodgepole pine	2	4	(0.3)	22	(7.3)	154	(58.7)
Mixed conifer	25	12	(1.1)	12	(1.4)	103	(20.1)
Mixed subalpine-mountain hemlock	13	11	(0.8)	31	(4.1)	86	(15.9)

[a] $\bar{x}$ = mean number per acre.
[b] (se) = standard error.
[c] White fir type in the Six Rivers and western Klamath National Forests.
[d] White fir type in the Mendocino, Shasta-Trinity, and eastern Klamath National Forests.

Table 8—Density of large-, medium-, and small-sized standing dead trees (snags) in pristine old-growth stands by forest type in northwestern California National Forests

Forest type	Number of stands	Large ≥30 inches in d.b.h. $\bar{x}$[a]	(se)[b]	Medium 20-28 inches in d.b.h. $\bar{x}$	(se)	Small 10-18 inches in d.b.h. $\bar{x}$	(se)
		Number of snags					
Douglas-fir/tanoak	37	2	(0.3)	1	(0.2)	5	(1.1)
Pacific Douglas-fir	37	3	(0.3)	2	(0.2)	3	(0.5)
White fir-a[c]	3	4	(0.4)	5	(1.6)	17	(1.3)
White fir-b[d]	5	3	(0.5)	4	(0.6)	6	(2.5)
Red fir	28	3	(1.2)	3	(2.5)	10	(12.2)
Jeffrey pine	6	1	(0.2)	1	(0.4)	1	(0.6)
Lodgepole pine	2	1	(0.2)	3	(0.5)	11	(2.2)
Mixed conifer	25	2	(0.3)	1	(0.2)	5	(0.9)
Mixed subalpine-mountain hemlock	13	2	(0.3)	2	(0.4)	6	(1.4)

[a] $\bar{x}$ = mean number per acre.
[b] (se) = standard error.
[c] White fir type in the Six Rivers and western Klamath National Forests.
[d] White fir type in the Mendocino, Shasta-Trinity, and eastern Klamath National Forests.

Table 9—Density of large-, medium-, and small-sized downed dead trees (logs) in pristine old-growth stands by forest type in northwestern California National Forests

Forest type	Number of stands	Large ≥30 inches in d.b.h. $\bar{x}$[a]	(se)[b]	Medium 20-28 inches in d.b.h. $\bar{x}$	(se)	Small 10-18 inches in d.b.h. $\bar{x}$	(se)
		Number of logs					
Douglas-fir/tanoak	37	3	(0.3)	6	(0.7)	10	(1.0)
Pacific Douglas-fir	37	3	(0.3)	7	(0.5)	11	(1.1)
White fir-a[c]	3	2	(1.0)	8	(0.8)	17	(6.4)
White fir-b[d]	5	2	(0.6)	6	(0.7)	12	(3.8)
Red fir	28	2	(0.3)	7	(0.8)	11	(1.3)
Jeffrey pine	6	1	(0.3)	3	(1.2)	6	(1.2)
Lodgepole pine	2	1	(0.8)	4	(3.0)	11	(1.4)
Mixed conifer	25	2	(0.3)	5	(0.8)	9	(1.5)
Mixed subalpine-mountain hemlock	13	2	(0.7)	7	(0.9)	11	(1.7)

[a] $\bar{x}$ = mean number per acre.
[b] (se) = standard error.
[c] White fir type in the Six Rivers and western Klamath National Forests.
[d] White fir type in the Mendocino, Shasta-Trinity, and eastern Klamath National Forests.

Table 10—Percentage of cover of trees, shrubs, and forbs in pristine old-growth stands by forest type in northwestern California National Forests

Forest type	Number of stands	Trees ≥5 inches in d.b.h. $\bar{x}$[a]	(se)[b]	Trees <5 inches in d.b.h. $\bar{x}$	(se)	Shrubs $\bar{x}$	(se)	Forbs $\bar{x}$	(se)
					Percent				
Douglas-fir/tanoak	37	75	(1.6)	45	(3.0)	21	(2.7)	19	(3.2)
Pacific Douglas-fir	37	60	(1.7)	43	(3.3)	24	(3.6)	26	(3.3)
White fir-a[c]	3	58	(2.9)	15	(5.3)	40	(19.5)	16	(5.9)
White fir-b[d]	5	42	(2.0)	17	(5.8)	16	(6.6)	11	(4.1)
Red fir	28	41	(1.9)	15	(1.5)	13	(3.0)	14	(2.5)
Jeffrey pine	6	34	(2.1)	14	(3.6)	19	(3.2)	21	(8.4)
Lodgepole pine	2	44	(12.2)	9	(2.3)	40	(8.8)	18	(1.8)
Mixed conifer	25	49	(4.4)	28	(3.8)	24	(4.1)	16	(3.3)
Mixed subalpine-mountain hemlock	13	43	(3.8)	19	(3.5)	7	(2.7)	15	(4.4)

[a] $\bar{x}$ = mean percentage of cover.
[b] (se) = standard error.
[c] White fir type in the Six Rivers and western Klamath National Forests.
[d] White fir type in the Mendocino, Shasta-Trinity, and eastern Klamath National Forests.

Tree species diversity—Douglas-fir/tanoak old growth is one of the more diverse old-growth types in northwestern California National Forests. Twenty-four tree species were found overall in the type. Any one stand of old growth averaged 8 tree species, and the maximum number of tree species found in a stand was 12. Below is a list of tree species in Douglas-fir/tanoak old growth with constancy greater than 10 percent:[5]

Species	Constancy
	Percent
Douglas-fir	100
Pacific madrone	86
Tanoak	84
Canyon live oak	43
Sugar pine	38
California black oak	32
Giant chinkapin	27
Bigleaf maple	24
Incense-cedar	16
Red alder	11

[5] Lists of tree species with constancies were derived from the trees greater than 5 inches in diameter that were tallied in the inventory.

Table 11—Average height of the canopy, regeneration, and shrub layers in pristine old growth by forest type in northwestern California National Forests

Forest type	Number of of stands	Canopy[a] $\bar{x}$[b]	Canopy[a] (se)[c]	Seedlings and saplings $\bar{x}$	Seedlings and saplings (se)	Shrubs $\bar{x}$	Shrubs (se)
		Feet					
Douglas-fir/tanoak	37	138	(3.3)	11	(0.7)	4	(0.4)
Pacific Douglas-fir	37	145	(4.1)	11	(0.6)	3	(0.3)
White fir-a[d]	3	118	(8.5)	6	(1.1)	3	(0.3)
White fir-b[e]	5	99	(5.7)	9	(0.3)	3	(0.8)
Red fir	28	104	(4.2)	8	(0.5)	2	(0.5)
Jeffrey pine	6	81	(6.2)	8	(0.6)	3	(0.2)
Lodgepole pine	2	78	(13.4)	8	(0.7)	2	(1.0)
Mixed conifer	25	110	(6.3)	9	(0.7)	3	(0.2)
Mixed subalpine-mountain hemlock	13	84	(3.7)	7	(0.6)	2	(0.5)

[a] Average of the dominant and codominant trees in each old-growth stand.
[b] $\bar{x}$ = mean height in feet.
[c] (se) = standard error.
[d] White fir type in the Six Rivers and western Klamath National Forests.
[e] White fir type in the Mendocino, Shasta-Trinity, and eastern Klamath National Forests.

Figure 14—Douglas-fir/tanoak old growth.

The large-sized trees—The largest tree measured in old-growth Douglas-fir/tanoak was a 90-inch Douglas-fir (Douglas-fir trees in fig. 14 are about 80 inches in diameter). The largest Douglas-fir on record is on the Olympic Peninsula in Washington; it is 173 inches in diameter (see table 4).

Ninety-one percent of the trees at least 30 inches in diameter in old-growth Douglas-fir/tanoak in northwestern California National Forests are Douglas-fir. Though sugar pine is a common associate in old-growth Douglas-fir/tanoak, it comprises only 2 percent of the trees at least 30 inches in diameter. Six percent of the trees at least 30 inches in diameter are hardwoods (see table 5). Tanoak, Pacific madrone, and canyon live oak are the primary hardwood species of this forest type. Though the three species do not grow to the heights of Douglas-fir and other conifer associates, they are capable of growing quite large in girth. The largest trees of these three species measured in this inventory were at least 5 feet in diameter, but they did not occur in old growth (see table 4). In old-growth Douglas-fir/tanoak, the largest tanoak was 46 inches, the largest Pacific madrone was 38 inches, and the largest canyon live oak was 36 inches.

Density of trees—Douglas-fir/tanoak old growth has, on average, 13 trees per acre that are at least 30 inches in diameter. The density of small-sized trees, primarily hardwoods, may, however, be one of the key characteristics that distinguishes the type from other old-growth types (see figs. 15 and 16). There are, on average, 171 trees per acre at least 5 inches in diameter and less than 20 inches in diameter. On average, 80 percent of the trees under 20 inches in diameter are hardwoods, and 46 percent of the trees between 20 and 28 inches in diameter are hardwoods.

Cover and height of vegetation layers—Most of the Douglas-fir/tanoak old growth has an even-sized upper canopy and a distinct understory. The two-storied structure of Douglas-fir/tanoak old growth—large-sized conifers above and generally tolerant hardwoods, especially tanoak, below—makes for the densest tree canopy overstory of all the old-growth types. The overstory percentage of cover in this type averages 75 percent. Even the seedling and sapling layer, consisting of trees less than 5 inches in diameter, is relatively dense, averaging 45 percent in cover and 11 feet tall. Pacific yew and Pacific dogwood are two tree species commonly found in the understory of old-growth Douglas-fir/tanoak. Pacific yew was found in 46 percent of the Douglas-fir/tanoak old-growth stands; Pacific dogwood was found in 76 percent of the stands.

Douglas-fir/tanoak and Pacific Douglas-fir old growth have the tallest overstories of the nine old-growth forest types described in this section. On average, the tree canopy is 138 feet tall in Douglas-fir/tanoak old growth, although many individual Douglas-fir trees measured over 200 feet in height. The tallest tree measured in the inventory was a 257-foot Douglas-fir. Although the tallest hardwood measured in Douglas-fir/tanoak old growth was a 97-foot canyon live oak and the tallest tanoak was 93 feet, the hardwood canopy in this old-growth type is generally less than a third of the height of the dominant conifers and averages about 45 feet.

Shrubs in Douglas-fir/tanoak old growth average 21 percent cover and 4 feet in height. Forbs average 18 percent cover. Thirty-three shrub species were tallied in the Douglas-fir/tanoak old growth.[6] The most common shrubs (they occurred in at least 10 percent of the stands) were Oregongrape, California hazel, poison oak, wild rose, deerbrush, and salal. The most common forbs were sword-fern and bracken.

[6] A true picture of understory diversity is not possible with the current inventory data, as the percentage cover of only the three most abundant species of conifers, hardwoods, shrubs, and forbs on any one subplot were recorded.

Figure 15—A few large Douglas-fir trees and an abundance of tanoak trees in old-growth Douglas-fir/tanoak.

Figure 16—The shorter hardwood canopy beneath the conifer canopy of old-growth Douglas-fir/tanoak.

Snags, logs, and decay—The average number of snags at least 20 inches in diameter in Douglas-fir/tanoak old growth is three per acre, the average number of logs at least 20 inches in diameter is nine per acre, and the average number of trees at least 20 inches in diameter with broken or dead tops or decay is three per acre.

Eighty-five percent of the snags at least 20 inches in diameter in the old-growth type are Douglas-fir, 5 percent are tanoak, 3 percent are canyon live oak, 2 percent are sugar pine, and 5 percent are other species. Ninety percent of the logs at least 20 inches in diameter are Douglas-fir, 5 percent are canyon live oak, 2 percent are tanoak, and 3 percent are other species.

Pacific Douglas-Fir Type

Area—The area of Pacific Douglas-fir pristine old growth in northwestern California National Forests is 136,178 acres or 35 percent of the total pristine old growth in these Forests (table 3). Twenty percent of the acres in Pacific Douglas-fir sawtimber is currently old growth. (Number of pristine old-growth stands = 37.)

Tree species diversity—Old-growth Pacific Douglas-fir is as diverse as Douglas-fir/tanoak old growth. Twenty-eight tree species were found overall with an average of nine species per stand. The maximum number of species in one stand was 12.

Below is a list of the most common tree species:

Species	Constancy
	Percent
Douglas-fir	100
Sugar pine	81
White fir	78
Pacific madrone	54
Ponderosa pine	38
Tanoak	38
Giant chinkapin	38
Incense-cedar	32
Bigleaf maple	32
California black oak	27
Canyon live oak	22
Pacific yew	11

The large-sized trees—The largest tree tallied in old-growth Pacific Douglas-fir was a Douglas-fir 88 inches in d.b.h. Although most of the large-sized trees in the old-growth type are Douglas-fir (85 percent), other conifers, primarily white fir and sugar pine, comprise 15 percent of the trees at least 30 inches in diameter (see table 5). The largest sugar pine tallied in the inventory was 82 inches in diameter and was tallied in an old-growth Pacific Douglas-fir stand. Less than 1 percent of the large-sized trees at least 30 inches in diameter are hardwoods in old-growth Pacific Douglas-fir.

Figure 17—Pacific Douglas-fir old growth lacks the evergreen hardwood understory of Douglas-fir/tanoak old growth.

Density of trees—Pacific Douglas-fir old growth averages 17 trees at least 30 inches in diameter per acre, slightly more than that found in Douglas-fir/tanoak old growth. The density of small- (<20 inches d.b.h.) and medium-sized (20 inches to 28 inches d.b.h.) trees in Pacific Douglas-fir old growth, however, is less than that of old-growth Douglas-fir/tanoak and is comprised of fewer hardwoods and a greater variety of conifers (see fig. 17). On average, a third of the trees less than 30 inches in diameter are conifers other than Douglas-fir in contrast to Douglas-fir/tanoak old growth where, on average, less than 2 percent of the small- and medium-sized trees are conifers other than Douglas-fir. In Pacific Douglas-fir old growth, 62 percent of the medium-sized trees are Douglas-fir, 14 percent are white fir, 6 percent are incense-cedar, 4 percent are sugar pine, and 14 percent are other species. Thirty-four percent of the small-sized trees are Douglas-fir, 25 percent are white fir, 6 percent are Pacific yew, 4 percent are other conifers, and 31 percent are hardwoods.

Cover and height of vegetation layers—Most Pacific Douglas-fir old growth has an even-sized upper canopy with an average height of 145 feet. Pacific Douglas-fir old growth has an average percentage of cover of 60 percent, which is less than the average overstory cover of Douglas-fir/tanoak old growth undoubtedly because there are fewer hardwoods in Pacific Douglas-fir old growth.

The regeneration understory of Pacific Douglas-fir old growth averages 43 percent of cover and 11 feet tall; and shrubs cover 24 percent averaging 3 feet tall. As in Douglas-fir/tanoak old growth, Pacific yew and Pacific dogwood are common trees in the understory of Pacific Douglas-fir old growth. Pacific yew was found in 40 percent of the old-growth stands, and dogwood was found in 78 percent of the stands.

Forty-one shrub species were found in Pacific Douglas-fir old growth, and the maximum tallied in any one stand was nine species. Common shrub species are vine maple, dwarf Oregongrape, deerbrush, California hazel, poison oak, currant, wild rose, willow, and red huckleberry.

Snags, logs, and decay—The incidence of decay is less in Pacific Douglas-fir than in any of the other old-growth types. On average, three live trees per acre show some form of decay. The average number of snags at least 20 inches in diameter in pristine Pacific Douglas-fir old growth is 5 per acre, and the average number of logs at least 20 inches in diameter is 10 per acre.

Seventy-five percent of the snags at least 20 inches in diameter are Douglas-fir, 10 percent are white fir, 6 percent are sugar pine, 4 percent are other conifers, and 5 percent are hardwoods.

White Fir Type in the Six Rivers and Western Klamath National Forests (White Fir-a)

Area—The area of pristine old-growth white fir in the Six Rivers and western Klamath National Forests is 4,501 acres or 1 percent of the total pristine old growth in these forests. The area represents 8 percent of the acres of sawtimber in the white fir type in the Six Rivers and western Klamath National Forests. (Eleven stands met the live tree criterion for old growth, and three stands met the definition for pristine old growth.)

The large-sized trees—The largest white fir measured in the inventory was 90 inches in diameter. The largest white fir on record with the American Forestry Association is 107 inches in diameter. Fifty-three percent of the trees at least 30 inches in diameter in pristine old-growth white fir in the Six Rivers and western Klamath National Forests are white fir and 43 percent are Douglas-fir. Although a small percentage of the white fir forest type is currently old growth, large-sized white fir trees are a characteristic of most of the old-growth types. The tabulation below shows the percentage of trees at least 30 inches in diameter in each old-growth type that are white fir and the percentage of snags at least 20 inches in diameter in each old-growth forest type that are white fir:

	White fir	
Old-growth type	**Trees**	**Snags**
	Percent	
Red fir	17	25
Lodgepole pine	9	5
Pacific Douglas-fir	6	10
Mixed conifer	14	30
Jeffrey pine	12	24
Mixed subalpine-mountain hemlock	5	5
White fir-a[7]	53	80
White fir-b[8]	67	88

[7] White fir type in the Six Rivers and western Klamath National Forests.

[8] White fir type in the Mendocino, Shasta-Trinity, and eastern Klamath National Forests.

Figure 18—The density of large trees, snags, and logs in white fir old growth is high.

Density and tree species diversity—The density of large-sized trees in old-growth white fir in the Six Rivers and western Klamath National Forests in both stands that meet the live tree criterion and in pristine old growth average 20 trees at least 30 inches in diameter per acre.

Thirteen tree species were found overall in old-growth white fir in the Six Rivers and western Klamath National Forests. The maximum number of species found in any one stand was 10. The most common associate of white fir in old-growth white fir in the Six Rivers and western Klamath National Forests is Douglas-fir. Other common associates are sugar pine, red fir, and incense-cedar. Although 43 percent of the trees at least 30 inches in diameter are Douglas-fir, white fir is the most abundant species in the small- and medium-sized classes. Ninety percent of the trees less than 20 inches in diameter are white fir.

Vegetation layers, cover, height—Most old-growth white fir in the Six Rivers and western Klamath National Forests has an even-sized canopy. The average height of the canopy is 118 feet tall, although individual trees measured over 200 feet. The tallest white fir measured in the inventory was 244 feet. The overstory is relatively dense, and the understory is relatively sparse (see fig. 18). The tree canopy averages 58 percent cover. The shrub cover in pristine old-growth white fir is 40 percent. There were only three plots, however, that met the pristine old-growth criterion, one of which had a shrub cover of 78 percent. The average shrub cover of the 11 stands that met the live tree criterion was 14 percent, and the most common shrub was California hazel.

Snags, logs, and decay—One of the distinguishing characteristics of old-growth white fir in the Six Rivers and western Klamath National Forests is the density of snags of all sizes. Sixty percent of the area that meets the large-sized live tree criterion for old growth has at least five large-sized snags per acre. In pristine old growth, the average number of snags at least 20 inches in diameter is nine snags per acre. The average density of snags less than 20 inches in diameter is 17 per acre in forest that meets the minimum live tree criterion for old growth as well as in pristine old growth.

In old-growth white fir in the Six Rivers and western Klamath National Forests, 80 percent of the snags at least 20 inches in diameter are white fir, 11 percent are Douglas-fir, and 6 percent are western white pine. White fir snags at least 20 inches in diameter are present in many of the old-growth forest types comprising 30 percent of the large-sized snags in old-growth mixed conifer, 25 percent of the large-sized snags in old-growth red fir, 24 percent of the large-sized snags in old-growth Jeffrey pine, 10 percent of the large-sized snags in old-growth Pacific Douglas-fir, 6 percent of the large-sized snags in old-growth mixed subalpine-mountain hemlock, and 5 percent of the large-sized snags in old-growth lodgepole pine.

The average density of logs at least 20 inches in diameter is 5 per acre in all white fir stands in the Six Rivers and western Klamath National Forests that meet the minimum live tree criterion for old growth and 10 per acre in pristine old-growth stands. Sixty-seven percent of the logs at least 20 inches in diameter are white fir, 22 percent are Douglas-fir, and 11 percent are other species. The average number of trees at least 20 inches in diameter with some form of defect in stands that meet the minimum live tree criterion is three trees per acre.

White Fir Type in the Shasta-Trinity, Mendocino, and Eastern Klamath National Forests (White Fir-b)

Area—The area of pristine old-growth white fir in the Shasta-Trinity, Mendocino, and eastern Klamath National Forests is 5,558 acres or 1 percent of the total old growth in these forests. The area represents 2 percent of the acres of sawtimber in the white fir forest type in the Shasta-Trinity, Mendocino, and eastern Klamath National Forests. (There were 14 stands that met the live tree criterion for old growth and 5 stands that met the definition for pristine old growth.)

The large-sized trees—Sixty-seven percent of the trees at least 30 inches in diameter in old-growth white fir in the Shasta-Trinity, Mendocino, and eastern Klamath National Forests are white fir, 11 percent are sugar pine, 11 percent are Jeffrey pine, 7 percent are incense-cedar, and 4 percent are other conifers. The largest tree measured in pristine old growth was a white fir 90 inches in diameter.

Density and tree species diversity—Average density of trees at least 30 inches in diameter is 12 trees per acre, somewhat less than the density of large-sized trees in white fir old growth in the Six Rivers and western Klamath National Forests.

Eleven species were found overall in old-growth white fir in the Shasta-Trinity, Mendocino, and eastern Klamath National Forests. The maximum for any one stand was six. The most common associates of white fir are sugar pine, Douglas-fir, Jeffrey pine, and incense-cedar. White fir is the most abundant species among the trees less than 30 inches in diameter. Seventy-five percent of the trees between 20 and 28 inches are white fir, 9 percent are Jeffrey pine, 10 percent are incense-cedar, and 6 percent are other conifers. Eighty-six percent of the trees less than 20 inches in diameter are white fir and 13 percent are Jeffrey pine. Although 11 percent of the trees at least 30 inches in diameter are sugar pine, less than 1 percent of the trees between 20 and 28 inches in diameter are sugar pine, and none of the trees less than 20 inches are sugar pine.

Cover and height of vegetation layers—Percentage of cover of the tree canopy averages 42 percent, somewhat lower than the percentage of cover of white fir old growth in the Six Rivers and western Klamath National Forests. This lower average percentage of cover may be because little of the old growth white fir has an even-sized canopy. Indeed, all the pristine old growth and 67 percent of the area that met the live tree criterion for old-growth white fir in the Shasta-Trinity, Mendocino, and western Klamath National Forests had at least three structural layers.

The main canopy of old-growth white fir in the Shasta-Trinity, Mendocino, and eastern Klamath National Forests averages 99 feet tall, although the tallest tree measured was a 192-foot white fir, and many individual trees measured over 150 feet tall. Average percentage of cover of shrubs is 16 percent, and the most common shrubs were whitethorn and snowberry, with an average height of 3 feet.

Snags, logs, and decay—Although there was no minimum snag criterion for the definition of old-growth white fir in the Shasta-Trinity, Mendocino, and eastern Klamath National Forests (see table 12 in appendix A), over 75 percent of the area that met the large-sized live tree criterion to be old growth had at least three 20 inches in diameter snags per acre. On average, in pristine white fir old growth in the Shasta-Trinity, Mendocino, and eastern Klamath National Forests there are seven snags at least 20 inches in diameter per acre and eight logs at least 20 inches in diameter per acre. The density of snags and logs in all size classes is somewhat less than that found in the pristine old-growth white fir in the Six Rivers and western Klamath National Forests. On average, six trees at least 20 inches in diameter per acre have some form of defect. This is the highest incidence of decay of all the old-growth types.

Red Fir Type

Area—The area of pristine red fir old growth in northwestern California National Forests is 25,330 acres, 12 percent of the total acres of sawtimber in the red fir type, which amounts to 6 percent of the total pristine old growth in these forests. (Number of pristine old-growth stands = 28.)[9]

Tree species diversity—There is little tree diversity in red fir old growth. On average, the type has three tree species per stand, and the maximum number of tree species found was seven. The most common associate to red fir is white fir, which occurred in 50 percent of the stands. Western white pine occurred in 20 percent of the stands, and mountain hemlock occurred in 14 percent (fig. 19 shows an old-growth red fir stand with western white pine on the eastern slopes of Mount Shasta). Few hardwoods occur in old-growth red fir.

Although old-growth red fir may have low tree diversity in any one area, the type lies among forest types of higher and lower elevation and thus has a wide variety of possible associates. Eighteen different tree species were found in the old-growth red fir type in this inventory.

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[9] The current inventory did not recognize the distinction between California and Shasta red fir, but we believe that most of the old-growth red fir type in these four forests is probably comprised of Shasta red fir.

Figure 19—Dense patches of large trees interspersed with open rocky areas in old-growth red fir on the slopes of Mount Shasta.

The large-sized trees—The largest red fir tallied on plots in this inventory was 70 inches in diameter and was tallied in an old-growth red fir stand. Though 70 inches is not close to the American Forestry Association record for California red fir of 102 inches in diameter, it is close to the record Shasta red fir, which is 78 inches in diameter. The largest tree tallied on a red fir old-growth plot was not red fir but a Douglas-fir, 78 inches in diameter. Eighty-one percent of the trees at least 30 inches in diameter in old-growth red fir type are red fir, 17 percent ar white fir, and 2 percent are other conifers.

Density of trees—The average density of large- and medium-sized trees in old-growth red fir is one of the highest of the old-growth forest types found in the northwestern California National Forests. On average, there are 19 trees at least 30 inches in diameter per acre and 27 trees between 20 and 28 inches in diameter per acre. In fact, the stand with the most trees at least 30 inches in diameter in the inventory was a red fir old-growth stand on which there were 32 large-sized trees per acre.

Cover and height of vegetation layers—The canopy of old-growth red fir averages 104 feet tall, similar to the canopy height of old-growth white fir, but about 30 to 40 feet shorter than the Douglas-fir old-growth types. The maximum height of a tree measured on an old-growth red fir plot was 195 feet. Though the density of large-sized trees in red fir old growth is greater than other types, the average percentage of cover of the overstory is just over 40 percent. The apparent contradiction can be understood by the fact that red fir stands often consist of dense clumps of old trees interspersed with patches of younger trees and openings that are often rocky (see fig. 19). This agrees with the inventory data that 60 percent of the red fir old-growth area had an uneven-sized canopy structure with three or more layers.

On average, the understory of old-growth red fir is sparse relative to some of the other old-growth types. Shrubs and seedlings together cover less than 30 percent of the area, and the shrubs average 2 feet tall. The most common understory shrubs are pinemat manzanita, bush chinkapin, gooseberry, and mountain mahogany. Forbs cover 14 percent of the ground, with lupine being the most common species.

Snags, logs, and decay—Although the ecological old-growth definition developed for the red fir type does not have a minimum snag requirement (see table 12 in appendix A), all 46,382 acres of the red fir type that have enough large-sized trees to qualify as old growth have at least one snag 20 inches in d.b.h. On average, pristine old-growth red fir has six snags per acre greater than or equal to 20 inches in diameter. Seventy-four percent of the snags at least 20 inches in diameter are red fir, 25 percent are white fir, and 1 percent are other conifers.

Eighty percent of the red fir old-growth area has at least six logs 20 inches in diameter and 10 feet long. In pristine old-growth red fir, there is an average of nine logs at least 20 inches in diameter per acre. On average, there are three live trees at least 20 inches in diameter per acre that have some form of decay.

Jeffrey Pine Type

Area—The area of pristine Jeffrey pine old growth in northwestern California National Forests is 26,761 acres. This represents 7 percent of the total pristine old growth in northwestern California National Forests but 46 percent of the sawtimber forest land in the Jeffrey pine type. (Number of pristine old-growth stands = 8.)

Trees species diversity—Jeffrey pine can be the dominant species in northwestern California on granitic ridgetops or where the soils are derived from serpentine rocks. The most common associate of Jeffrey pine is incense-cedar, a species also able to tolerate infertile ultramafic soils and thus outcompete other species. Incense-cedar was found on all the old-growth Jeffrey pine stands. Other associates of old-growth Jeffrey pine in northwestern California are white fir, Douglas-fir, sugar pine, and red fir. The total number of tree species found in old-growth Jeffrey pine was 11.

The large-sized trees—The largest Jeffrey pine measured in the inventory was 68 inches in diameter, though it was not found in old growth. The two largest trees found in old-growth Jeffrey pine were Douglas-fir (64 inches in diameter), and incense-cedar (60 inches in diameter). The largest Jeffrey pine found in Jeffrey pine old growth was 52 inches in diameter.

Seventy-three percent of the trees at least 30 inches in diameter in Jeffrey pine old growth are Jeffrey pine, 12 percent are white fir, 10 percent are incense-cedar, and 5 percent are other conifers.

Density of trees—Jeffrey pine old growth has one of the lowest densities of trees of all the old-growth types in northwestern California, averaging 87 trees per acre (see fig. 20). On average, there are 7 trees per acre at least 30 inches in diameter and 12 trees per acre between 20 and 28 inches in diameter. The species composition of the trees between 20 and 28 inches in diameter is similar to that of the large-sized trees in old-growth Jeffrey pine: 73 percent are Jeffrey pine, 13 percent are white fir, 7 percent are incense-cedar, and 7 percent are other conifer species. Jeffrey pine and white fir, however, are equally abundant among trees less than 20 inches in diameter. No hardwoods greater than 5 inches in diameter were found in old-growth Jeffrey pine.

Cover and height of vegetation layers—Three quarters of the old-growth Jeffrey pine has an uneven canopy structure with three or more distinct structural layers (table 6). Average percentage of cover of the overstory is 34 percent, lower than in any of the other old-growth types.

Figure 20—Open stand of old-growth Jeffrey pine.

The tallest trees in old-growth Jeffrey pine are 100 feet shorter than those in Douglas-fir or mixed-conifer old-growth types and 50 feet shorter than the white fir and red fir old-growth types. The tallest tree measured in old-growth Jeffrey pine was a 141-foot Douglas-fir. The tallest Jeffrey pine measured was 137 feet. The upper canopy of old-growth Jeffrey pine averages 81 feet.

Shrub cover in old-growth Jeffrey pine averages 19 percent and 3 feet tall. Twenty shrub species in all were found in old-growth Jeffrey pine. The most common were snowberry, whitethorn, pinemat manzanita, greenleaf manzanita, and squaw carpet. Forbs, primarily grass, average 21 percent cover.

Snags, logs, and decay—On average, there are two snags per acre at least 20 inches in diameter and four logs per acre at least 20 inches in diameter in old-growth Jeffrey pine. Sixty-four percent of the snags at least 20 inches in diameter are Jeffrey pine, 24 percent are white fir, 10 percent are incense-cedar, and 2 percent are other conifers. Seventy-five percent of the logs at least 20 inches in diameter are Jeffrey pine, 11 percent are incense-cedar, 8 percent are white fir, and 6 percent are other conifers. On average, two trees at least 20 inches in diameter per acre have some defect.

Lodgepole Pine Type

Area—The area of pristine old-growth lodgepole pine in northwestern California National Forests is 2,923 acres or 1 percent of the total old growth on these forests. Four percent of the acres of sawtimber in the lodgepole pine forest type is currently old growth. (There were four stands that met the minimum live tree criterion for old growth and two pristine old-growth stands.)

Figure 21—Dense cover of pinemat manzanita in old-growth lodgepole pine.

Stand characteristics—In northwestern California, lodgepole pine is found in association with Jeffrey pine, ponderosa pine, western white pine, red fir, white fir, and mountain hemlock. In this inventory, only 7 percent of the sawtimber lodgepole pine area was in pure pine stands. In addition, although lodgepole pine may make up the plurality of stocking, the largest trees in the type are often not lodgepole pine. Seventy-three percent of the trees at least 30 inches in diameter in old-growth lodgepole pine were red fir, 15 percent were western white pine, and 9 percent were white fir, and 3 percent were mountain hemlock; none were lodgepole pine. The largest lodgepole pine measured in the inventory was 32 inches, but it was not found in old growth. The overstory of old-growth lodgepole pine is shorter than most of the other old-growth types. On average, the upper canopy is 78 feet tall.

In general, lodgepole pine old growth is distinguished from other old-growth types in northwestern California by the density of small-sized trees and the percentage of cover of the shrub layer, which is often denser than the cover of the tree canopy (see fig. 21). Most of the small-sized trees are lodgepole pine. The percentage of cover of shrubs averages 40 percent and is less than 2 feet tall. The most common shrub is pinemat manzanita. Other common shrubs are squaw carpet and huckleberry oak. Overall density of snags is greater in old-growth lodgepole pine than some of the other types because of the density of snags less than 20 inches in diameter (see table 8).

Mixed-Conifer Type

Area—There are 55,732 acres of pristine old growth in the mixed-conifer type, which is 14 percent of the pristine old growth in northwestern California National Forests. Thirty-seven percent of the acres of sawtimber in the mixed-conifer type is large-sized sawtimber, and 5 percent is currently pristine old growth. (Number of pristine old-growth stands = 25.)

Tree species diversity—Tree diversity of old-growth mixed-conifer is comparable to the tree diversity found in the old-growth Douglas-fir types. On average, eight tree species are found in mixed-conifer old growth. Overall, 28 tree species were found in old-growth mixed conifer in northwestern California National Forests. Below is a list of the tree species in mixed-conifer old growth with constancy greater than 10 percent.

Species	Constancy
	Percent
White fir	84
Douglas-fir	80
Sugar pine	68
Incense-cedar	56
Ponderosa pine	32
Jeffrey pine	28
Giant chinkapin	28
Red fir	24
Canyon live oak	16
Tanoak	16
Pacific madrone	16
Port-Orford cedar	12
Bigleaf maple	12

The large-sized trees—Forty-five percent of the trees at least 30 inches in diameter in old-growth mixed conifer are Douglas-fir, 14 percent are white fir, 13 percent are sugar pine, 7 percent are incense-cedar, 5 percent are ponderosa pine, 6 percent are hardwoods, and 10 percent are other conifers such as Port-Orford-cedar, Brewer spruce, Jeffrey pine, red fir, western white pine, and western juniper. The largest tree measured in old-growth mixed conifer was a Douglas-fir 84 inches in d.b.h.

Density of trees—The density of medium- and large-sized trees in old-growth mixed conifer is similar to both the Douglas-fir old-growth types. Mixed-conifer old growth has, on average, 12 trees per acre at least 30 inches in diameter, and 12 trees per acre between 20 inches and 28 inches in diameter. The density of trees under 20 inches in diameter, 103 trees per acre, is more similar to the density of small-sized trees in Pacific Douglas-fir old growth than Douglas-fir/tanoak old growth.

Figure 22—Sugar pine is frequently found in old-growth mixed conifer.

Some of the complexity of old-growth mixed conifer is due to the diversity of conifer species (see fig. 22). The diversity of conifer species in old-growth mixed conifer is apparent in all size classes, though the mix of conifer species is not the same across size classes. Douglas-fir is the most abundant conifer among the large-sized trees and shares dominance with white fir in the medium-sized trees. White fir is the most abundant conifer in the small-sized trees. Although 13 percent of the large-sized trees are sugar pine, only 4 percent of the medium-sized trees and 1 percent of the small-sized trees are sugar pine. The percentage of trees that are incense-cedar (7 percent) is constant across the size classes.

Vegetation layers, cover, and height—Most of the old-growth mixed conifer has less than three structural layers and averages 110 feet tall, though there are occasional trees that measure over 200 feet. The tallest tree measured in old-growth mixed conifer was a 257-foot Douglas-fir, the second tallest was a 244-foot white fir.

Overstory percentage of cover in old-growth mixed conifer averages 49 percent. Average percentage of cover of seedlings and saplings is 28 percent with an average height of 9 feet. The most common seedling or sapling in old-growth mixed conifer is white fir which was found in 92 percent of the stands. Although present, Pacific yew is not as common in old-growth mixed conifer as in the Douglas-fir types. It was found in less than 12 percent of the old-growth stands.

Average percentage of cover of shrubs is 24 percent, and average height is 3 feet. Of 36 shrub species tallied in old-growth mixed conifer, 18 had a constancy of at least 10 percent. The most common shrubs were snowberry, wild rose, greenleaf manzanita, pinemat manzanita, whitethorn, Oregongrape, and currant. Average percentage of cover of forbs is 16 percent.

Snags, logs, and decay—The average number of snags at least 20 inches in diameter in old-growth mixed conifer is three per acre, and the average number of logs at least 20 inches in diameter is seven per acre. Thirty-three percent of the 20-inch in d.b.h. snags are Douglas-fir, 30 percent are white fir, 15 percent are sugar pine, 10 percent are ponderosa pine, 5 percent are incense-cedar, 4 percent are other conifers, and 3 percent are hardwoods. In old-growth mixed conifer, 51 percent of the 20-inch in diameter logs are Douglas-fir, 26 percent are white fir, 10 percent are ponderosa pine, 4 percent are incense-cedar, 4 percent are sugar pine, 4 percent are other conifers, and less than 1 percent are hardwoods. On average, there are three trees at least 20 inches in diameter per acre with some form of decay.

Mixed Subalpine–Mountain Hemlock Type

Area—The area of pristine old-growth mountain hemlock in northwestern California National Forests is 9,056 acres or 2 percent of the total pristine old growth in these forests. Thirty-six percent of the acres of mountain hemlock sawtimber is currently old growth. (Number of pristine old-growth stands = 13.)

Tree species diversity—Tree species diversity is relatively low in mountain hemlock old growth. The most tree species found on any one plot was seven species and the average was four. The most common associate of mountain hemlock is red fir, which had a constancy of 77 percent in old-growth mountain hemlock. The most common associates of mountain hemlock in mountain hemlock old growth at elevations above the red fir forest type are western white pine, foxtail pine, and whitebark pine.

The large-sized trees—The largest mountain hemlock measured in the inventory was 62 inches and was found in old growth. It was also the largest tree measured in old-growth mountain hemlock. The largest whitebark pine found in the inventory was 34 inches, the largest western white pine was 62 inches, and the largest foxtail pine found was 46 inches. All three of these trees are less than half the size of the records for each species (see table 5).

Forty-six percent of the trees at least 30 inches in diameter in old-growth mountain hemlock are mountain hemlock, and 47 percent are red fir. Seven percent are other conifers.

Density of trees—On average, there are 11 trees per acre at least 30 inches in diameter and 31 trees per acre between 20 and 28 inches in diameter in old-growth mountain hemlock. The average density of trees less than 20 inches is 86 trees per acre. Seventy-five percent of the trees less than 30 inches in diameter are mountain hemlock. Red fir comprises 24 percent of the trees between 20 and 28 inches in diameter and 13 percent of the trees less than 20 inches in diameter.

Vegetation layers, cover, and height—Most of the old-growth mountain hemlock has an uneven canopy with at least three distinct structural layers. Trees tend to grow in clumps, or even singly, where there is enough soil to support their growth (see fig. 23). Average percentage of cover of the tree canopy is 43 percent. Trees range in stature from fairly well-formed trees over 100 feet tall (the tallest tree measured in old-growth mountain hemlock was 165 feet tall) to those that are twisted and stunted. The upper canopy averages 84 feet tall.

The shrub understory of old-growth mountain hemlock is sparse with an average of 7 percent cover and averages 2 feet tall. The most common shrub is pinemat manzanita. Forbs average 15 percent cover.

Figure 23—Old-growth mountain hemlock.

Snags, logs, and decay—Although the old-growth definition for mountain hemlock is one-tenth of a snag (30 inches in diameter) per acre (see table 12 in appendix A), 93 percent of the mountain hemlock sawtimber area that meets the large-sized live tree criterion for old growth has at least three snags at least 20 inches in diameter per acre. On average, there are four snags per acre at least 20 inches in diameter in pristine old-growth mountain hemlock. In addition, although there is no minimum criterion of logs, 84 percent of the mountain hemlock type that meets the large-sized live tree criterion has at least six logs per acre at least 20 inches in diameter. On average, there are nine pieces at least 20 inches in diameter per acre in pristine old-growth mountain hemlock. On average, four trees per acre at least 20 inches in diameter have some form of decay.

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Appendix A

Source of Data for Old-Growth Definitions

The primary source of data for the old-growth definitions were Region 5 ecosystem classification plots. These plots were a cluster of three points. At each point, trees were tallied on a variable prism plot. Species, diameter, age, and height were recorded for all trees. Plant species and percentage of cover of all canopy layers—tree, shrub, herb, and grass—were recorded, and subjective information on structural features and canopy layers was noted. Points were from 66 to 132 feet apart. Thus, a plot covered, at minimum, about 1 acre. There was no limit for the size of the stands. On many ecosystem classification plots, snags, logs, and tree decay were not recorded. For that reason, separate data sets were used to supplement the ecosystem classification plots for these structural attributes. Supplemental data sets came from the existing timber inventories for each National Forest. This data set was similar in design to the ecology plots, but used a five-point "L" shaped cluster plot, all other tree and snag data being essentially the same. Downed dead trees were not measured in the timber inventories.

Techniques Used to Develop Old-Growth Definitions

The plots were stratified by SAF type and site class. The age of the oldest tree measured was used to represent the age of the stand. Trend analysis was employed to determine at what age most of the structural attributes changed from mature to old growth. The age where this occurred was the cutoff from which statistics were calculated by site class for the key structural attributes of old growth. In some old-growth definitions, in addition to trend analysis, the plots were stratified by site and age class, and discriminant analysis was used to identify those variables that could best discriminate old-growth from mature stands.

The Key Structural Characteristics of Old-Growth Definitions

Table 12 below lists the minimum criterion for each of the three primary components (density and size of trees, snags, and logs) of the old-growth definitions. Note that some of the components are further subdivided by size. Thus, in the high-site interior ponderosa pine forest type, the minimum criterion for live trees is at least 15 trees per acre ≥21 inches in diameter including three trees per acre ≥30 inches in diameter. For many of the types, the minimum snag criterion or log criterion was reported as zero. This would seem to indicate that the component was not useful in distinguishing old-growth from mature sawtimber. The methods to collect snags (often variable prism plots) on the cluster plots used for classification, however, may have been too small to sample snags, which occur in low density. The result was a high variance for estimates of number of snags per acre. In addition, the number of samples available for estimating coarse woody debris (logs) was much smaller than that used for live trees and may have been insufficient to give an adequate minimum criterion for this component.

Table 12—Key structural characteristics of the definitions of old growth in California forest types

Forest type	Site class	Minimum stand age	Live trees		Standing dead trees		Down dead trees		
			Diameter	Minimum	Diameter	Minimum	Diameter	Length	Minimum
		Years	*Inches*	*No. per acre*	*Inches*	*No. per acre*	*Inches*	*Feet*	*No. per acre*
Douglas-fir/tanoak	High	180	40	4	20	0.5	20	10	2
	Medium	240	30	9	20	0.5	20	10	2
	Low	300	30	4	20	0.5	20	10	2
Pacific Douglas-fir	High	180	40	6	20	1	20	10	5
	Medium	260	30	11	20	1	20	10	5
	Low	295	25	15	20	1	20	10	5
White fir-a[a]	High	180	30	14	20	3	20	10	5
	Medium	240	30	11	20	3	20	10	5
	Low	300	25	26	20	3	20	10	5
White fir-b[b]	High	143	39	7			10 and 20	10	6.1 and 5.2
	Medium	188	39	6			10 and 20	10	6.1 and 5.2
	Low	239	29	6			10 and 20		6.1 and 5.2
Red fir	High	150	30	12			30		0.1
	Low	200	30	7			30		0.6
Pacific ponderosa pine	High	125	30[c] 15[d]	11	Any size	2	Any size		1
	Low	145	30[c] 15[d]	2	Any size	2	Any size		1
Interior ponderosa pine	High	150	21[e] and 30	30 3					
	Low	200	21	13					
Jeffrey pine	High	150	30	4.3					
	Low	200	30	2.2					
Lodgepole pine	High	150	25	10					
	Low	200	25	3					
Mixed conifer	High	188	39	8					
	Medium	253	39	6					
	Low	256	29	5					
Mixed subalpine-western white pine	High	150	30	5					
	Low	200	30	7					
Mountain hemlock	High	150	30	8					
	Low	200	30	7	30	0.1			
White fir/Jeffrey pine	High	150	30	7	30	0.1			
	Low	200	30	3	30	0.3			

[a] White fir type in the Six Rivers and western Klamath National Forests.
[b] White fir type in the Mendocino, Shasta-Trinity, and eastern Klamath National Forests.
[c] 30 inches for conifers.
[d] 15 inches for hardwoods.
[e] 30 trees 21 inches in diameter, and 3 trees 30 inches in diameter.

Appendix B
Key to SAF Forest Types in California

1. If greater than 33 percent total basal area is redwood, then type is **SAF 232 redwood**.

2. If greater than 33 percent total basal area is Port-Orford-cedar, then type is **SAF 231 Port-Orford-cedar**.

3. If greater than 25 percent total basal area is lodgepole pine, then type is **SAF 218 lodgepole pine**.

4. If greater than 80 percent total basal area is ponderosa pine and plot is east of the Sierra crest, then type is **SAF 237 interior ponderosa pine.**

5. If greater than 80 percent total basal area is ponderosa pine and plot is west of the Sierra crest, then type is **SAF 245 Pacific ponderosa pine**.

6. If greater than 50 percent total basal area is Jeffrey pine, then type is **SAF 247 Jeffrey pine**.

7. If greater than 80 percent total basal area is comprised of ponderosa pine and Jeffrey pine:

- If plot is east of Sierra crest and there is more ponderosa pine than Jeffrey pine, then type is **SAF 237 interior ponderosa pine.**
- If plot is east of Sierra crest and there is more Jeffrey pine than ponderosa pine, then type is **SAF 247 Jeffrey pine**.
- If plot is west of Sierra crest and there is more ponderosa pine than Jeffrey pine, then type is **SAF 245 Pacific ponderosa pine**.
- If plot is west of Sierra crest and there is more Jeffrey pine than ponderosa pine, then type is **SAF 247 Jeffrey pine**.

8. If plot consists solely of ponderosa pine and juniper and greater than 50 percent total basal area is in ponderosa pine, then type is **SAF 237 interior ponderosa pine**.

9. If greater than 50 percent of total basal area is white fir and plot is in the Six Rivers National Forest or in the Ukonom, Happy Camp, or west Salmon River districts of the Klamath National Forest, then type is **SAF 211 white fir-a**.

10. If greater than 60 percent of total basal area is white fir and plot is NOT in the Six Rivers National Forest or in the Ukonom, Happy Camp, or west Salmon River districts of the Klamath National Forest, then type is **SAF 211 white fir-b**.

11. If greater than 10 percent total basal area is comprised of western white pine, whitebark pine, mountain hemlock, aspen, or foxtail pine:

- If greater than 60 percent of the total basal area is comprised of white fir, red fir, and Jeffrey pine, and if red fir is present, both Jeffrey pine and white fir are also present, then type is **SAF 256-c mixed subalpine-white fir/Jeffrey pine**
- If greater than 50 percent of the total basal area is comprised of western juniper, then type is **SAF 256-d mixed subalpine-western juniper.**
- If greater than 50 percent of the total basal area is comprised of aspen, then type is **SAF 256-e mixed subalpine-aspen.**

- If greater than 30 percent of the total basal area is comprised of mountain hemlock, and the mountain hemlock basal area exceeds western white pine, then type is **SAF 256-b mixed subalpine-mountain hemlock**.
- If greater than 20 percent of the total basal area is comprised of western white pine, then type is **SAF 256-a mixed subalpine-western white pine.**
- If greater than 20 percent of the total basal area is comprised of foxtail pine, or whitebark pine, or Brewer spruce, then type is **SAF 256-b mixed subalpine-mountain hemlock (by proxy)**.

12. If greater than 50 percent of total basal area is red fir, then the type is **SAF 207 red fir.**

13. If greater than 80 percent of total basal area is comprised of red fir and white fir:

- If there is more red fir than white fir, then type is **SAF 207 red fir**.
- If there is more white fir then red fir and plot is in the Six Rivers National Forest or the Ukonom, Happy Camp, or west Salmon River districts of the Klamath National Forest, then type is **SAF 211 white fir-a**.
- If there is more white fir than red fir and plot is NOT in the Six Rivers National Forest or the Ukonom, Happy Camp, or west Salmon River districts of the Klamath National Forest, then type is **SAF 211 white fir-b.**

14. If greater than 50 percent of total basal area is Douglas-fir (or if Douglas-fir is the sole conifer) and evergreen hardwoods (tanoak, Pacific madrone, canyon live oak) comprise at least 10 percent of total basal area and white fir is absent, then type is **SAF 234 Douglas-fir/tanoak**.

15. If greater than 50 percent of total basal area is Douglas-fir and evergreen hardwoods (tanoak, Pacific madrone, canyon live oak) comprise less than 10 percent of the total basal area or white fir is present, then type is **SAF 229 Pacific Douglas-fir.**

16. If greater than 50 percent of the total basal area is comprised of a combination of Douglas-fir, ponderosa pine, white fir, incense-cedar, sugar pine, black oak, Jeffrey pine, or red fir, then type is **SAF 243 mixed conifer.**

Appendix C
Common and Scientific Names of Trees, Shrubs, and Forbs

Common name	Scientific name
Softwood trees:	
White fir	*Abies concolor* (Gord. & Glend.) Lindl. ex Hildebr.
California red fir	*Abies magnifica* A Murr.
Noble fir	*Abies procera* Rehd.
Port-Orford-cedar	*Chamaecyparis lawsoniana* (A. Murr.) Parl.
Western juniper	*Juniperus occidentalis* Hook.
Incense-cedar	*Libocedrus decurrens* Torr.
Brewer spruce	*Picea brewerana* Wats.
Engelmann spruce	*Picea engelmannii* Parry ex Engelm.
Whitebark pine	*Pinus albicaulis* Engelm.
Knobcone pine	*Pinus attenuata* Lemm.
Foxtail pine	*Pinus balfouriana* Grev. & Balf.
Lodgepole pine	*Pinus contorta* Dougl. ex Loud.
Jeffrey pine	*Pinus jeffreyi* Grev. & Balf.
Sugar pine	*Pinus lambertiana* Dougl.
Western white pine	*Pinus monticola* Dougl. ex D. Don.
Ponderosa pine	*Pinus ponderosa* Dougl. ex Laws.
Gray pine	*Pinus sabiniana* Dougl.
Douglas-fir	*Pseudotsuga menziesii* (Mirb.) Franco
Pacific yew	*Taxus brevifolia* Nutt.
Western redcedar	*Thuja plicata* Donn ex D. Don
Mountain hemlock	*Tsuga mertensiana* (Bong.) Carr.
Hardwood trees:	
Bigleaf maple	*Acer macrophyllum* Pursh
Red alder	*Alnus rubra* Bong.
Pacific madrone	*Arbutus menziesii* Pursh
Giant chinkapin	*Castanopsis chrysophylla* (Dougl.) A. DC.
Pacific dogwood	*Cornus nuttalli* Audubon
Oregon ash	*Fraxinus latifolia* Benth.
Tanoak	*Lithocarpus densiflorus* (Hook. & Arn.) Rehd.
Quaking aspen	*Populus tremuloides* Michx.
Black cottonwood	*Populus trichocarpa* Torr. & Gray
Canyon live oak	*Quercus chrysolepis* Liebm.
Blue oak	*Quercus douglasii* Hook. & Arn.
Oregon white oak	*Quercus garryana* Dougl. ex Hook.
California black oak	*Quercus kelloggii* Newb.
California valley oak	*Quercus lobata* Nee
Interior live oak	*Quercus wislizenii* A. DC.
California-laurel	*Umbellularia californica* (Hook. & Arn.) Nutt.

Common name	Scientific name
Shrubs and forbs:	
Vine maple	*Acer circinatum* Pursh
Greenleaf manzantia	*Arctostaphylos patula* Greene
Pinemat manzanita	*Arctostaphylos nevadensis* Gray
Bush chinkapin	*Castanopsis sempervirens* (Doug. ex Hook.) A. DC.
Deerbrush	*Ceanothus integerrimus* Hook. & Arn.
Squaw-carpet	*Ceanothus prostratus* Benth.
Whitethorn	*Ceanothus cordulatus* Kellogg
Mountain-mahogany	*Cercocarpus* sp. Kunth
California hazel	*Corylus cornuta* var. *californica* (A. DC.) Sharp
Salal	*Gaultheria procumbens* L.
Lupine	*Lupinus* sp. L.
Oregongrape	*Mahonia nervosa* (Push) Nutt.
Sword-fern	*Polystichum munitum* (Kaulf.) K Presl
Bracken	*Pteridium aquilinum* (L.) Kuhn
Huckleberry oak	*Quercus vacciniifolia* Kellogg
Poison oak	*Rhus diversiloba* Torr. & Gray
Currant	*Ribes* sp. L.
Gooseberry	*Ribes roezlii* Regel
Wild rose	*Rosa* sp. L.
Willow	*Salix* sp. L.
Snowberry	*Symphoricarpos albus* L. Blake
Red huckleberry	*Vacinnium parvifolium* Smit

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This report estimates old-growth forest area and summarizes stand characteristics of old growth in northwestern California National Forests by forest type. Old-growth definitions for each forest type are used.

Keywords: Old growth, inventory, forest stands, forest area, California, National Forests, Douglas-fir, white fir, red fir, Jeffrey pine, ponderosa pine, lodgepole pine, mixed conifer, mountain hemlock, mixed subalpine.

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